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ABSTRACT

This study was conducted to determine whether the traditional classroom approach to instruction involving the addition and subtraction of number facts (digits 0-6) is more or less effective than the traditional classroom approach plus a commercially-prepared computer game. A pretest-posttest control group design was used with two groups of first grade students--N=15 for the experimental group and N=14 for the control group--and their relative gains in achievement were compared. The computer game used by the experimental group in addition to regular classroom instruction was Alligator Mix, which is designed to help students increase their skills in both adding and subtracting numbers 0-9 by feeding alligators in the swamp. Since the game has the ability to establish increasingly more difficult levels for mastery, students are required to memorize and recall the number facts without stopping to determine the answers. The study lasted 20 school days and a t-test was used to measure the significance of difference between the mean gains of the two groups. Six data tables display the findings of the study, and conclusions indicate there were no significant differences between the experimental and control group in mathematical gains involving the addition and subtraction of number facts; however, both groups did show significant gain. Recommendations for future study and a list of 32 references complete the document. (JB)

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THE EFFECTS OF COMPUTER-ASSISTED INSTRUCTION ON STUDENT ACHIEVEMENT IN ADDITION AND SUBTRACTION AT FIRST GRADE LEVEL

Applied Project

Education 799

Augusta College

In Partial Fulfillment of the Requirements

for the

Degree of Educational Specialist

by

Patsy M. Spivey

March 1985

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CHAPTER I

INTRODUCTION

Context of the Problem

With the advent of microcomputer technology, educators have been challenged to consider the advisability of its utilization in the instructional programs of the schools. Mass media campaigns have tried to make the public believe that every child from the preschooler to the college student is disadvantaged if he/she does not have ready access to a user-friendly, electronic teacher.

Encouraged by advertising, consumers have begun to purchase microcomputers. Substantial investments have been made in the acquisition of hardware by the public as well as by the schools. It is estimated that 11 percent of the homes and 52 percent of the schools already have microcomputers. General surveys of the community point out that most people believe that it is the school's responsibility to provide computer literacy in addition to the three R's.

Computer-assisted instruction is not new. Programmed materials have been available with or

without the accompanying hardware for more than twenty years. The uniqueness of the situation at this time is its economic feasibility. The introduction of microcomputers that are relatively affordable and readily available has created the concern.

Decisions related to the place of computer instruction at the middle school and secondary level seem to be centered around curricula for exploration, word processing, elementary programming and actual utilization in advanced courses. Instructional programs for the gifted student at the elementary level frequently introduce exploration activities. However, the most appropriate utilization of microcomputers in the early grades does not appear to have been firmly established. While many educators continue to evaluate the cost effectiveness of placing computer te ology in the lower grades, they suddenly find that the hardware is in place and the decision becomes how to use it rather than whether or not to make the purchase. Everyone from the children to the teacher, the school secretary to the custodian seems to be fascinated and intrigued with the novel acquisition. The challenge then becomes to decide how to integrate the equipment as well as the excitement into the curriculum.

The elation of both the public and school leaders has been somewhat dampened by the fact that many have purchased microcomputers only to find that they do not know how to use them. It becomes quite frustrating to have expensive equipment gather dust while the news media continue to emphasize its problem solving capabilities.

Statement of the Problem

The purpose of this study was to determine whether the traditional classroom approach to instruction involving the addition and subtraction of number facts (digits 0-6) is more or less effective than the traditional classroom approach incorporating a commercially-prepared computer game.

Significance of the Study

The significance of this study is that it provided an alternative and supplemental solution to teaching the addition and subtraction facts using the traditional textbook and regular classroom instruction. Due to the ability to establish increasingly more difficult levels for mastery, the computer game requires that the students memorize and recall the number facts without stopping to determine the answers. However, immediate recall is an advanced stage of development as compared

to working out the answer by counting or using a number line. This concept is one that many students fail to attain at the primary level as can be evidenced by teacher observation in first and second grade classrooms.

CHAPTER II

SURVEY OF THE LITERATURE

A concerted effort was made to conduct a thorough review of the literature to glean information concerning the use of microcomputers in the elementary school. An ERIC (Education Resources Information Center) search was secured. Using the descriptors primarily limited to microcomputers:elementary:mathematics:instruction, 29 articles were located. Most of these items were published in the early eighties and dealt with a variety of subjects.

Many of the articles were related to securing microcomputers and placing them in the schools. There were a number of short descriptive essays printed in journals such as the Arithmetic Teacher, Creative Computing and Computer Teacher. Little of the material was devoted to well-designed studies in which the effectiveness of computer-assisted instruction was examined.

Firestein (1984), Swafford (1984) and Beckwith (1984) pointed out the excitement related to the new equipment as well as the need for further research to establish the most appropriate uses for instruction. Linda Gojak (1983) spoke of the ease of operating

microcomputers while Wiburg and Rader(1984) discussed the speed at which teachers as well as students could become comfortable using the hardware.

The most appropriate place in the school for the equipment seems to be somewhat of an issue. Boya (1984) wrote about his use of a microcomputer housed in a single classroom. As would be expected, the equipment's usage according to this author was limited solely to the acquisition of appropriate software and the ingenuity of the teacher. Hart (1984) discussed her schedule for providing computer instruction to 425 students with a single computer. She responded to the problems of housing the equipment in a media center and seemed to prefer the classroom setting.

Only a few of the materials reviewed made mention of the importance of teacher training in the use of this equipment in the elementary schools. This was possibly due to the fact that the descriptors for the ERIC search were limited to the use of microcomputers in the teaching of a specific area, arithmetic. However, teacher training is an issue as can be demonstrated in the number of college courses and staff development offerings listed across the country. Although some are hesitant, many teachers are anxious to learn.

Finding time in the busy elementary curriculum for computer activities also seems to have become an issue. However, due to the unique interest and motivation of students in microcomputers alternatives have been posed. Hart (1984) offered instruction in computer literacy after the regular school hours. Olsen (1984) found that deaf children preferred working with the computer to going out to recess. These children were learning language art skills in an interesting and rewarding way. Although most teachers would suggest that a microcomputer be installed in every classroom, the economic feasibility of this approach at this time is doubtful.

The place of computer literacy in the elementary curriculum was the main idea of several articles. Bloomstrand (1984) suggested that enrichment was a prime usage in elementary schools. Certainly microcomputers have been placed in programs for gifted children long before they have been available to the regular class program.

Many educators are aware of the problem of securing appropriate software to use with microcomputers. White and others (1984) discussed computer networking with

commercially-prepared software. Carlisi and Judd (1984) published an article on the ease of networking. Schilling (1984) wrote a review of educational software for instructional purposes while Shumway (1984) discussed using software related to graphing as a viable reinforcement.

Murphy (1983) published a lengthy summary of available software for education. He provided the format, language, price, manufacturer and a brief description of each piece. He made little effort to evaluate these materials in light of their educational effectiveness.

The literature was filled with the controversy of whether to use the microcomputers at the elementary level to teach programming or merely for drill and reinforcement as well as enrichment. Markuson and others (1983) reported at some length about "Logo Fever." Logo, a commercial program designed to teach young children to program, was used. She believed that the time was well-spent teaching programming at the elementary level.

Feeney (1982) described a microcomputer mini curriculum that could be used in the schools while Noraman and Parker (1982) discussed the advantages of

using different languages --Basic vs Logo-- at the elementary level. Although all of the educators accepted the fact that computer programming should be included in the curriculum, none of them suggested what might be eliminated to provide the time.

Using the microcomputer as a learning machine was the main topic of a few studies. Rather than using the equipment to teach, the microcomputer was viewed as an avenue to provide drill and practice as well as reinforcement. (Martin, 1981)

The idea of using the new technology to provide opportunities for problem solving activities was well-developed in the literature. In 1982, Totsye and others pointed out the value of microcomputers in expanding approaches to problem solving experiences. He believed that this was an area the classroom teacher frequently found little time for in the normal school day.

Clements (1983) published a similar article on the merits of programming, problem solving and practice using microcomputers in the curriculum. He concluded that problem solving and practice were more valuable uses at the elementary school level.

Articles directly related to the use of

microcomputers for drill and practice of arithmetic skills particularly at the primary level were limited. Kraus (1982) placed computers in learning centers in classrooms for a period of four weeks. He was most interested in teacher/student attitude as well as evaluating software. He found that the instructional games can provide an easy, low-stress, enjoyable introduction to microcomputers for the students as well as teachers.

In a well-documented study, Morris (1983) reported significant gains in achievement in mathematics after a four week intervention with commercial computer games at the sixth grade. She observed that commercial materials provided an avenue to readily integrate computer activities into the regular mathematics curriculum. She cautioned educators to be careful in selecting appropriate software that was educationally sound. She suggested that problem solving was an excellent area to stress in choosing computer activities. Emphasis should also be given to selecting games that are truly interactive, one in which the child has control. And finally, it is necessary to provide paper and pencil activities for maximum transfer.

The requirement that adequate computer games must

be interactive was also pointed out by Sadowski (1983). She stated that this feature eliminated the objection to early computer-assisted instructional programs that tended to program the students rather than to provide interaction.

Heck (1983) used microcomputers in the primary grades. He found that if these materials were viewed as supplemental to an existing mathematics curriculum they would be more beneficial.

Attisha and Yazdani (1983) reported a rather complicated study in which they developed a microcomputer based tutor for teaching arithmetic skills. The work was conducted in The Netherlands. It was envisioned to be used by student teachers who might not have the skills to diagnose specific weaknesses and to plan accordingly. This was one of the first efforts to develop a program to use the computer to teach.

The development of instructional computer games must make use of learning theory if the games are to be deemed appropriate for instruction. Arcademic Skill Builders in Math is a series published by DLM Teaching Resources. It features a combination of microcomputer

software and supplementary print materials to present a total approach to learning arithematic facts. The program stems from experience, systematic observations, and research in attempting to understand student learning in school and social situations. The program incorporates the advantages of current electronic and educational technology to provide educators with a fresh approach to teaching and learning.

The microcomputer software features fast action, colorful graphics, and compelling arcade game format to both motivate and teach students arithmetic facts. The supplemental materials, flashcards and worksheets allow additional individualization and practice for building skills which can later be challenged by the computer game. (See appended on pages 36-38.) The use of a progress chart allows both the teacher and student to to systematically record performance information, observe changes in performance, and to make performance based decisions about immediate and long curriculum needs. (See appended on page 39.) The collaboration between student and teacher offers the teacher the the opportunity to become the manager of student learning rather than the tutor.

This series was written by a professor, Jerry

Chaffin, from the University of Kansas. He based his effort in part on the earlier work of Ogden Lindsley in Precision Teaching. It provides success in learning, meets the individual needs of students, and provides a high rate of learning. It is a series of fast action games with increasing levels of difficulty.

The overall purpose of Arcademic Skill Builders in Math is to assist students in learning basic arithmetic facts of addition, subtraction, multiplication and division through motivational practice. Such practice will provide the students with consistent recall of these facts in more complex math operations and in everyday situations.

For the purposes of this study the program, Alligator Mix, was selected. The microcomputer software is described by the developer as follows:

> Alligator Mix will help students increase their skills in both adding and subtracting number 0-9 by feeding alligators in the swamp. As alligators appear in the swamp, apples with addition and subtraction problems move toward the alligator's mouth. Answers appear in the stomach of the of the alligator. As the apple with the problem approaches the alligator's mouth, the player

must determine if the answer in the alligator is the correct one for the approaching problem. If so, the player opens the alligator's mouth by pressing one of the designated keys to allow it to eat the apple. If the alligator is fed an incorrectly-matched problem, it will suffer the the effects of a "bad" apple; if a correct match is made, the alligator will tell the player how good the meal was. If the student misses giving the alligator a good apple, it will grumble. If a no-match is correctly determined by the player, the apple will spin and disappear. Five alligators will appear in the swamp in a single game and be fed ten apples each. The speed of the 'feeding' of the alligators increases as more alligators appear. Hits and misses are recorded in the swamp at the bottom of the screen. This program is especially good for generalization of both addition and subtraction skills. (Chaffin, pp. 6-7)

CHAPTER III

PLANNING AND CONDUCTING THE STUDY

Research Hypothesis

In learning number facts there is a difference in achievement between those who use computer games and those who do not. The literature indicated that the learning theories used to construct computer games would have an affect on mathematical achievement. (Chaffin and Maxwell, 1982) However, few studies have been published citing the actual effect that such instructional materials have on achievement.

Sigrason and Olson (1983) reported statistically significant gains of elementary students in mathematical computation after six months of daily practice using computer software. Attisna and Yazdani (1983) published similar findings in the Instructional Science.

Null Hypothesis

In teaching mathematics (number facts) there is no statistically significant difference in achievement between subjects who use computer games and those who do not.

Identification of Variables

Independent variable(s): Computer games

Level 1: Use of computer games

Level 2: Non-use of computer games

Dependent variable(s): Mathematical achievement involving number facts as measured by an informal test

Moderator variable(s): None

Control variable(s): Grade level of students

Intervening variable(s): Learning
Motivation
Learning modality

Operational Definitions of Variables

Computer game — Alligator Mix, a commercially prepared computer game available from DLM Teaching Resources, Allen, Texas

Achievement — 80 percent competency on an informal

timed test

First grade students	Students currently enrolled in a first grade class at Peter H. Craig Elementary School
Classroom approach	Classroom instruction following the Richmond County Elementary Curriculum Guide and utilizing related materials provided by the system

Description of the Research Design

The pretest and posttest control group design was used in conducting the study. The rationale behind the use of this design was that the researcher had the freedom to randomly assign the subjects that participated in the study. The project used an intact class that called for the utilization of a pretest to ascertain group equivalence prior to the beginning of the study. The pretest-posttest control group design can be diagrammed as shown below:

$$\begin{array}{lll} R & O_1 & X \quad O_2 \\ \hline R & O_3 & \quad O_4 \end{array}$$

R - Random assignment of subjects

O_1 - Pretest for experimental group

X - Use of computer game

O_2 - Posttest for experimental group

O_3 - Pretest for control group

O_4 - Posttest for control group

Population and Sample

The target population of the study was a first grade class (N=29) at Peter H. Craig Elementary School in Richmond County, Georgia. The class population consisted of approximately 17 percent White and 83 percent Black. The majority of the students were at or near grade level expectancy. The socioeconomic level of the group was reflected by the fact that more than 90 percent received free or reduced lunch. Using the random number table (Walker and Lev, 1953), one group was selected to represent the experimental group (N=15) while the other children were to comprise the control group (N=14).

Instrumentation and Data Collection

Both groups were taught mathematics by the same

teacher using the 1978 edition of Heath Mathematics First Grade Level as the text for instruction. The only difference was that in addition to regular classroom instruction one group used a computer game composed of addition and subtraction facts (digits 0-6) for drill and reinforcement. The experimental group used the combination of regular classroom instruction and computer games whereas the control group was allowed to to receive only regular classroom instruction.

During the first week of the study, both groups were given a pretest to ascertain the equivalence of the group in terms of the dependent variable. Two commercially prepared worksheets were used. (Copies appended on pages 40-41.)

Both the control group and the experimental group were instructed by the classroom teacher. The study lasted twenty school days. The experimental group was divided into groups of three. They received fifteen minutes of drill a day at the computer in addition to the regular classroom instruction. All of the computer centered activities were based on Alligator Mix, which was described in Chapter II.

On the last day of the study, all of the students

were given a posttest. The same instrument used for the pretest was used for the posttest. A comparison of the mean gains on the posttest scores was used to determine the effectiveness of each approach. Since there was a significant difference in the pretest scores of the randomly selected groups, mean gains were computed for each group and the difference was tested for significance.

Data Analysis

The statistical test applied was the t-test. It was applied to the pretest results to check on the initial group equivalency and the gain scores of the control and experimental groups to determine the significance of difference in achievement.

Assumptions and Limitations

In conducting the study, several assumptions and limitations had to be considered. This investigation was limited to one heterogenously-grouped first grade class that was representative of an inner city school with a high percentage of low socioeconomic minority children. It was possible that the instrument used for the pretest and posttest was not as valid and reliable as a standardized instrument.

It was assumed that the teacher of the two groups would in no way try to influence the outcome of the study. It was also assumed that the computer game, Alligator Mix, would reinforce or teach the skills that were to be tested. In addition, the time span allotted for the study would be long enough to properly assess the two approaches.

CHAPTER IV

ANALYSIS OF DATA

The pretest was administered to the first grade class (N=29) as a group. After using a random number table to select the experimental and control group, a statistical test was applied to the pretest scores to determine the initial group equivalency. The researcher applied the t-test

$$\underline{t} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2} \cdot \frac{(N_1 + N_2)}{N_1 N_2}}}$$

to test the hypothesis that there was no statistically significant difference between the means of the experimental and control group. On the basis of the $\underline{t}$ - test, it was determined that a difference did exist. Table 1 is used to illustrate the results.

Further analysis of the differences between the two groups was made. Using the Otis-Lennon School Abilities Test administered at the beginning of the school year, a

comparison of the academic functioning of the control group and the experimental group was calculated. While the mean IQ of the total group was 85.93, there was a ten point difference in potential school ability between the control and experimental groups. Table 2 is used to illustrated the results.

TABLE 1

INITIAL GROUP EQUIVALENCY

	Control	Experimental	t	df
N	14	15		
Mean	25.643	34.667	-2.344	27
S.D.	10.696	10.33		

Probability < .025 (one-tail)

Probability < .05 (two-tail)

TABLE 2

MENTAL ABILITIES

	Number	Mean IQ	Range IQ	Range %
Total	29	85.93	63-111	1-75
Control	14	80.30	63-93	1-48
Experimental	15	90.20	69-111	3-75

Based on Otis-Lennon School Abilities Test administered in September, 1984

Since it was determined that there was a statistically significant difference between the two randomly selected groups, it was decided to examine the mean gains to establish whether the null hypothesis could be rejected. Table 3 is employed to demonstrate the gains made by each group.

TABLE 3

RAW SCORES PRETEST/POSTTEST

	Pretest Groups		Posttest Groups		Difference	
Subjects	Exp	Con	Exp	Con	Exp	Con
1	18	12	32	27	14	15
2	23	13	27	27	4	14
3	24	15	31	21	7	6
4	24	16	32	26	8	10
5	28	18	35	47	7	29
6	31	21	59	19	28	-2
7	32	23	58	22	26	-1
8	33	27	60	41	27	14
9	36	27	39	38	3	11
10	42	32	44	46	2	14
11	44	33	54	54	10	21
12	44	35	50	37	6	2
13	45	40	60	46	15	6
14	46	47	59	51	13	4
15	50		59		9	

On the basis of the t-test, the null hypothesis --- in teaching mathematics involving number facts, there is no statistically significant difference in achievement between those who use computer games and those who do not --- could not be rejected. (df = 27; t = -.110; p = .91) Table 4 shows the analysis of data.

TABLE 4

ACHIEVEMENT OF CONTROL AND EXPERIMENTAL GROUPS

	Control	Experimental	t	df
N	14	15		
Mean	11.000	11.333	-.110	27
S.D.	8.647	7.678		

Probability < .91 (one-tail)

Probability < .999 (two-tail)

However, in examining the gains made by the total group, there was a statistically significant difference. Both of the groups made more progress during the three week period than would have been expected. Table 5 is used to demonstrate the analysis of the gains made by the experimental group. Table 6 shows the same data for the control group.

TABLE 5

ANALYSIS OF MEAN GAINS

EXPERIMENTAL GROUP

Subjects	N	Mean	S.D
Pretest	15	34.667	10.033
Posttest	15	46.000	12.201

t = -5.717; d.f. = 14; Probability < .001

TABLE 6

ANALYSIS OF MEAN GAINS

CONTROL GROUP

Subjects	N	Mean	S.D.
Pretest	14	25.643	10.696
Posttest	14	36.643	13.030

t = -4.760; d.f. = 13; Probability < .01

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The researcher examined the use of computer games with the traditional classroom approach to determine if the utilization of this educational technology was related to mathematical proficiency in the addition and subtraction of number facts. This study showed no significant differences at the .05 level between the programs. Therefore, the researcher was not able to to reject the null hypothesis. Although there was no significant difference, all of the students made positive gains. The researcher believes that if the study had been conducted over a longer period of time, there may have been a significant difference.

Conclusions

Results of this study indicate that there was no significant difference between the experimental and control group in mathematical gains involving the addition and subtraction of number facts. However, the experimental group did show a greater gain than the control group. In addition, the gains of both groups were significant.

The researcher did note the use of microcomputer games appeared to instill a positive attitude toward the operations of addition and subtraction of number facts. Evidence to support this statement was observed by the researcher as well as the teacher. The students would rush to the classroom sessions and were anxious to remain for a longer session.

The control group seemed anxious to join their computing counterparts. However, the control group was told that they would have an opportunity to use the computer later. Some of the positive gains of this group may well be attributed to their attempts to "earn computer time."

Recommendations

Based on the results of the study, the following recommendations are made:

1. A similar study should be conducted earlier in the school year. The students in both groups may exhibit a higher gain or one group could score significantly higher than the other

2. In a follow-up study, the posttest should contain more items. The number of students that made a perfect score should be

reduced which would possibly result in higher mean gains

3. Similar studies should be conducted with older students to determine if the effectiveness of microcomputer games is more of less significant than the traditional approach at the higher grade levels

REFERENCES

Attisna, M. & Yazdani, M. (1983). A micro-computer based tutor for teaching arithmetic skills. Instructional Science, 12 (4), 333-42.

Beckwith, M.P. (1984). Computer corner: News from the classroom. Arithmetic Teacher, 31 (8), 49-50.

Bloomstrand, N.L. (1984). Kids with computers: An enrichment program for elementary school children. Arithmetic Teacher, 31 (5), 12-15.

Boya, R. (1983). A sample of teaching with a microcomputer-a single classroom. Computing Teacher, 10 (9), 60-61.

Bugeliski, B. R. (1964). The psychology of learning applied to teaching. New York: Bobbs-Merrill.

Carlisi, D. & Judd, R. (1984). Networking doesn't have to be hard. Electronic Education, 3 (4), 41-42.

Clements, D. H. (1983). Programming, problem solving, and practice. Arithmetic Teacher, 31 (4), 32-35.

Connor, T. & others. (1981). A plan for a mathematics curriculum with a focus on problem solving for elementary grades K-5.. Gainsville: University of Florida, P. K. Yonge Laboratory School.

Feeney, J.E. (1982). A microcomputer minicurriculum. Arithmetic Teacher, 29 (5), 39-42.

Firestein, L. (1984). Arithmetic 400. A computer educational program. Paper presented at the Annual Spring Conference of Computer Using Educators. 4th, University of Southern California.

Gojak, L.M. (1983). Taking the first step with a computer. Arithmetic Teacher, 30 (7), 34-40.

Grady, M.T. & Gawronski, J.D. (1983). Computers in curriculum instruction. Alexandria, Va: Association for Supervision and Curriculum Development.

Hart, L.C. (1984). How can 425 students learn to use 1 microcomputer? A success story. Arithmetic Teacher, 31 (5), 16-17.

Heck, W. (1983). Teaching mathematics with microcomputers: Primary grades. Arithmetic Teacher, 30 (6), 63-66.

Kansky, R. (1983). The cpu and you. Arithmetic Teacher, 30 (6), 12-13, 52-54.

Kraus, W.H. (1982). The use of microcomputers for mathematics instruction in grades 1-4 (Report No. SED-80-12268). Springfield, OH: Wittenberg University. (ERIC Document Reproduction Service No. ED 229 240).

Leonard, G.E. (1983). Counting on your apple. Incider, 1 (6), 30-31.

Markuson, C. & others. (1983). Logo fever: The computer language every school is catching. Arithmetic Teacher, 31 (1), 48-51.

Martin, K. (1981). The learning machines. Arithmetic Teacher , 29 (3), 19-21.

Morris, J.P. (1983). Microcomputers in a sixth-grade classroom. Arithmetic Teacher, 31 (2), 22-24.

Murphy, B.J. (1983). Educational programs for the very young. Creative Computing, 9 (10), 10-18.

Nordman, R. & Parker, J. (1981). Teaching computer literacy in an elementary school: A comparison of two methods using microcomputers (Report No. 81: 18). Vancouver: Educational Research Institute of British Columbia. (ERIC Document Reproduction Services No ED 213 400).

Olsen, J.B. (1982). Do I have to go to recess? Electronic supplements in language instruction. American Annals of the Deaf, 127 (5), 602-608.

Runyon, R.P., & Haber, A. (1974). Fundamentals of behavioral statistics. Reading, MA: Addison-Wesley.

Schilling, R. (1981, November). Elementary, my dear apple. Popular Computing, pp. 78,80.

Shumway, R.J. (1984). Computer corner: Graphing. Arithmetic Teacher, 31 (5), 56.

Shumway, R.J. (1984). Computer corner: Try this: computer counting. Arithmetic Teacher, 31 (6), 57-58.

Si rdson, S.E. & others. (1983, April). Utilization of microcomputers in elementary mathematics, final report. Edmonton, Canada: Alberta Department of Education.

Swafford, J. (1984). One point of view: Making room. Arithmetic Teacher, 31 (7), 2.

Walker, H. M., & Lev, J. (1953). Statistical Inference, New York: Holt, Rinehart, & Winston.

White, M.R. & others. (1983, April). Computer networking with commercially prepared software. Paper presented at the Annual International Convention for the Council for Exceptional Children. San Francisco, CA.

Wilburg, K. & Rader, B. (1984). Computers are elementary. Arithmetic Teacher, 31 (5), 18-22.